

# The effect of agricultural nutrient loading on estuarine bacterioplankton communities

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# What is Microbial Ecology?

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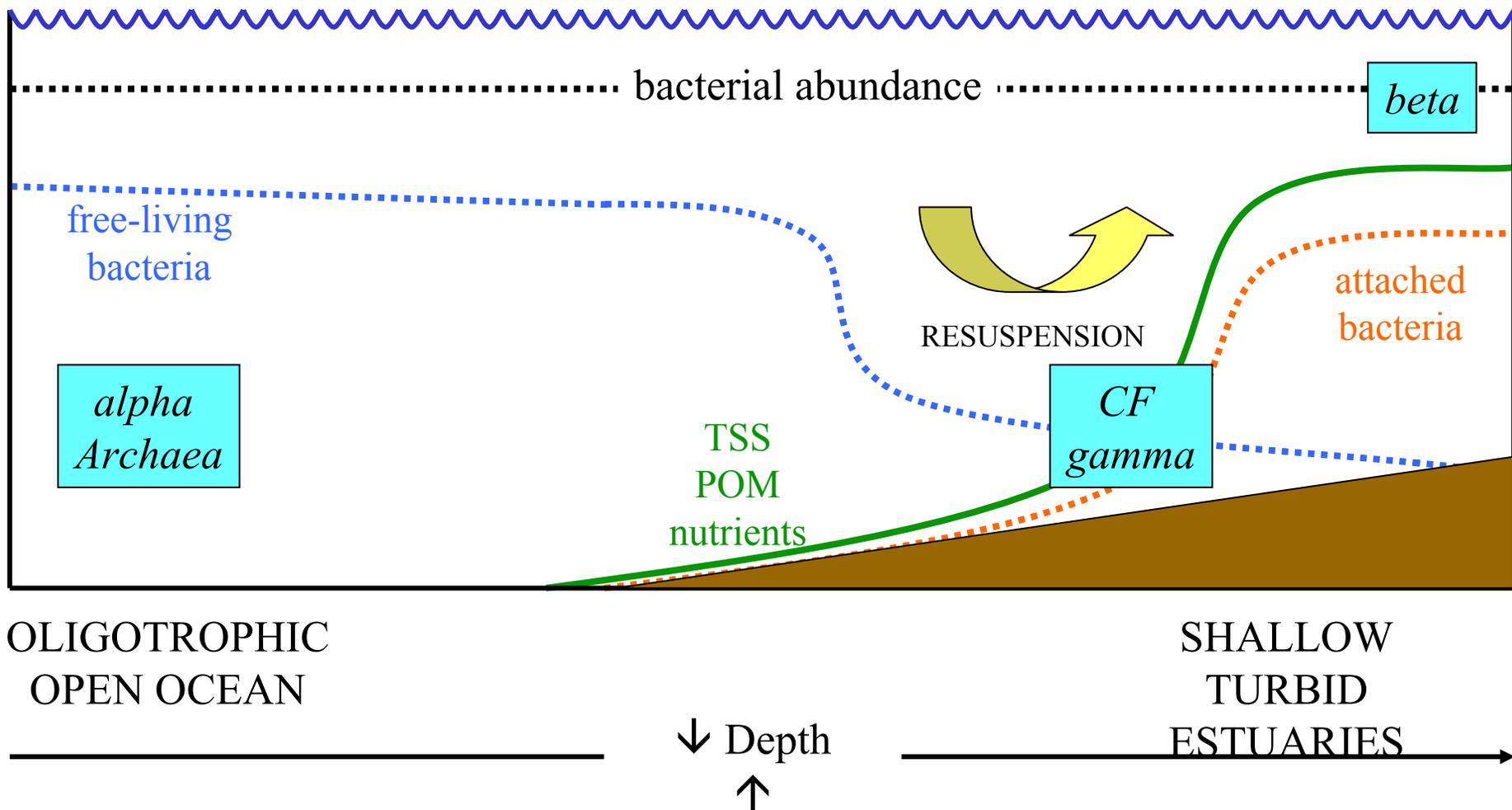
- Ecological Processes and Plankton Dynamics
- Paradigm Shifts
  - Cultured vs. Non-cultured Bacterioplankton
  - Dominance of Heterotrophic Processes
- Technological Advances
  - Flow Cytometry
  - Production and Respiration Measurements
  - Molecular Techniques
- Where are we today?
  - Empirical estimates of bacterial respiration
  - Relative contribution among and within systems
  - Diversity

# Heterotrophic Bacterioplankton

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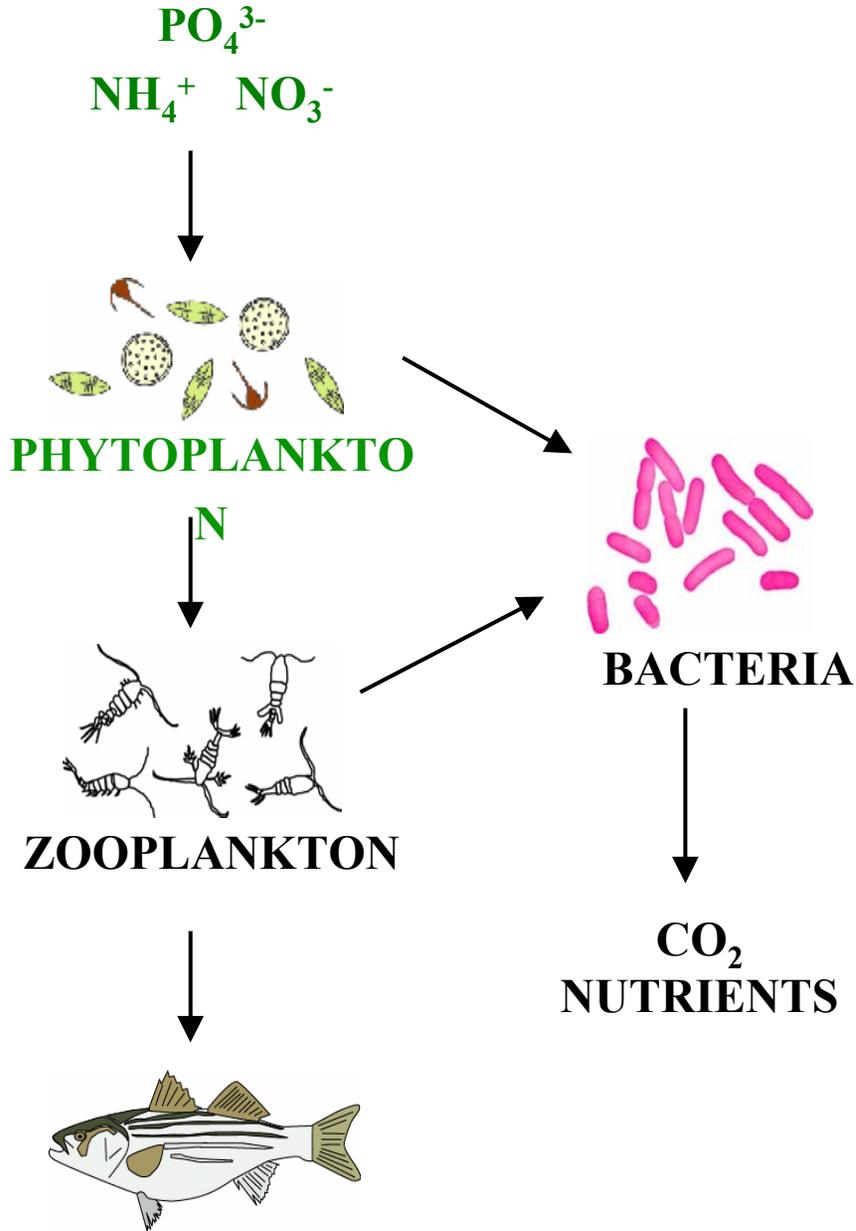
- Non-pathogenic!
- Small ( $\leq 1\ \mu\text{m}$ )
- Abundant ( $\sim 10^6$  cells/ml)
- Comparable in biomass to PP
- Nutrient & carbon remineralization
- Drive water quality parameters (i.e. anoxia, nutrient availability)
- Source vs. sink?

# Cross-System View of Bacterioplankton



# Plankton Dynamics of Aquatic Systems

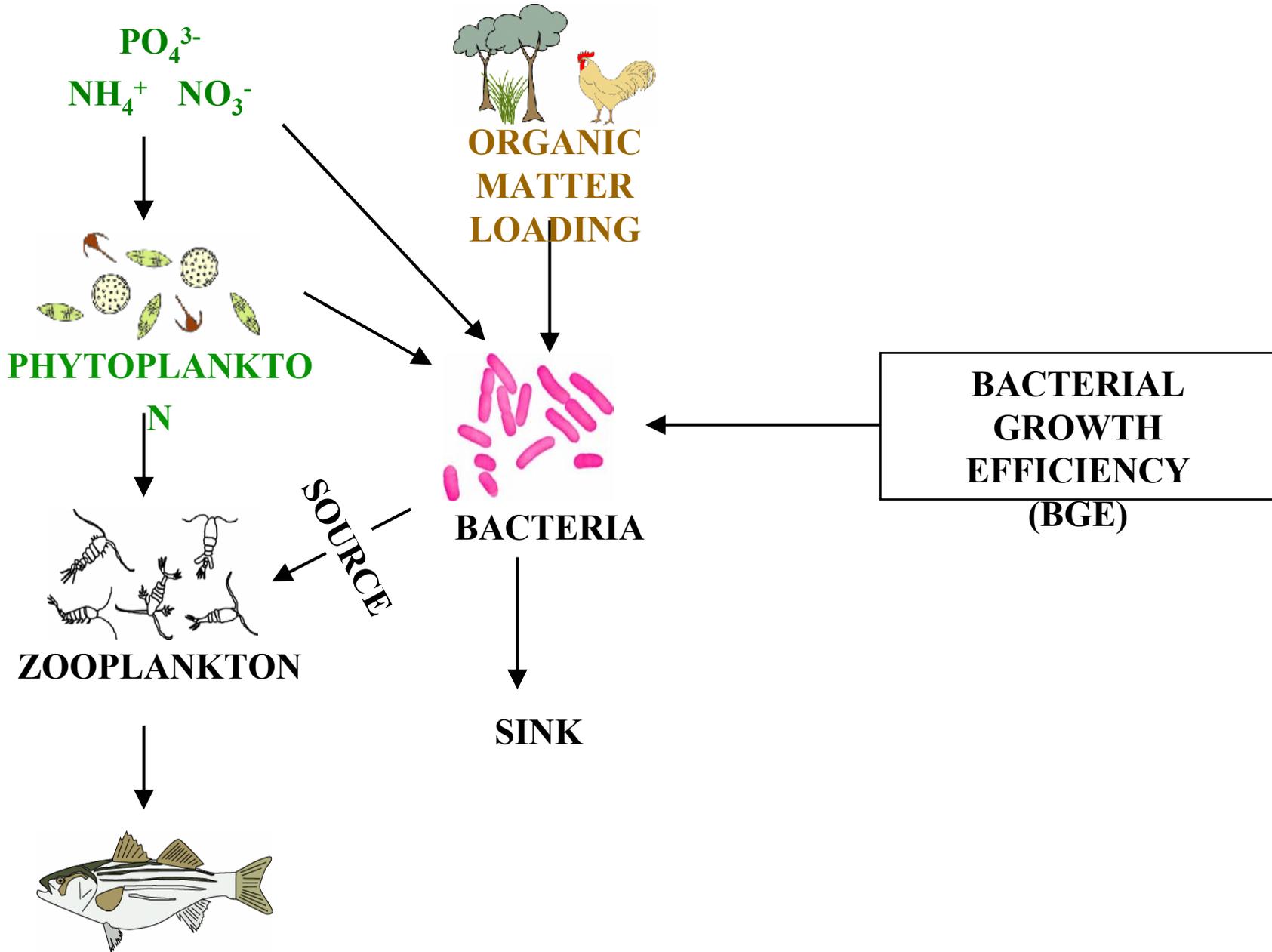
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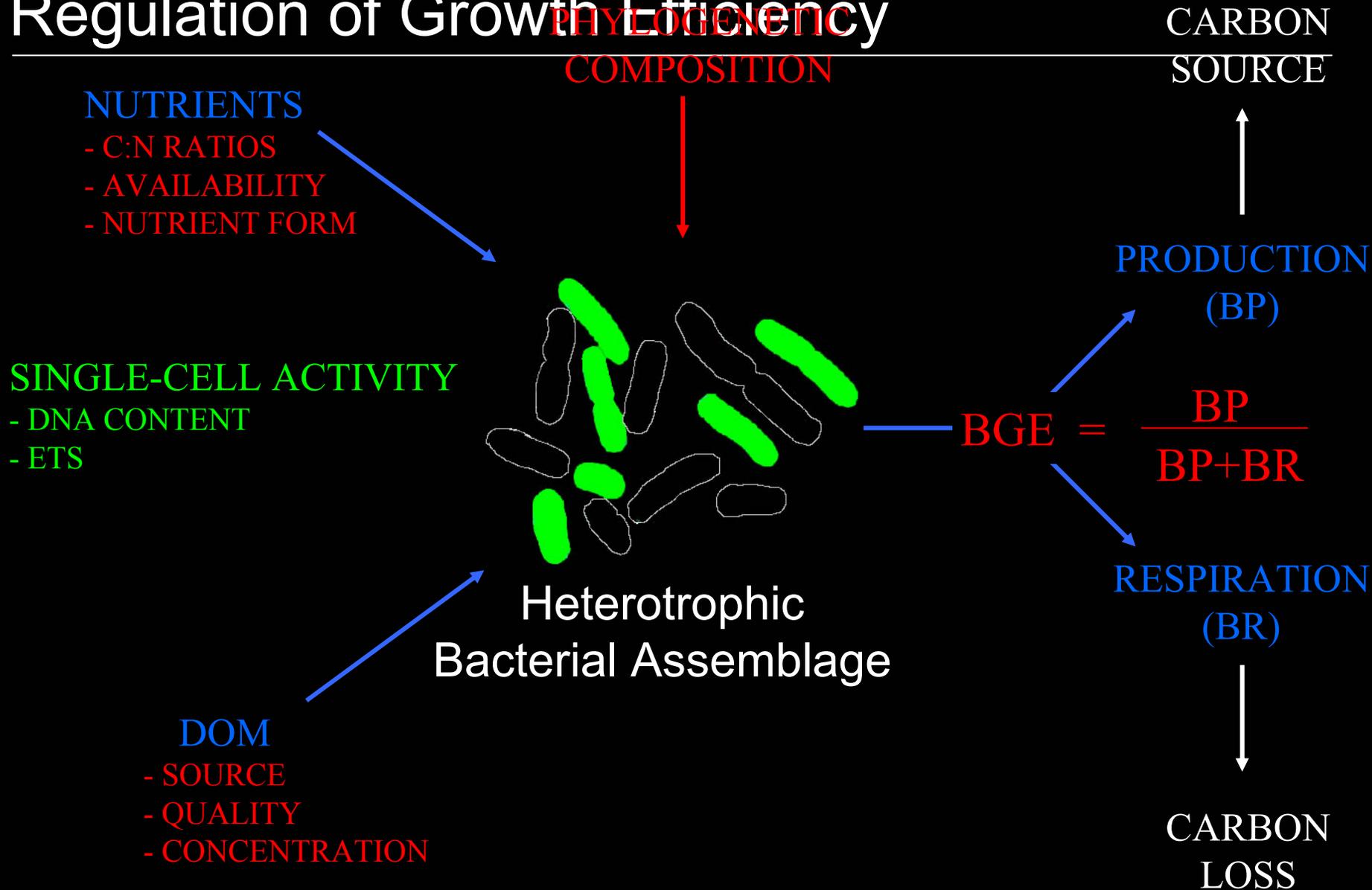


# Direct vs Indirect Effects of Nutrient Enrichment

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# Regulation of Growth Efficiency



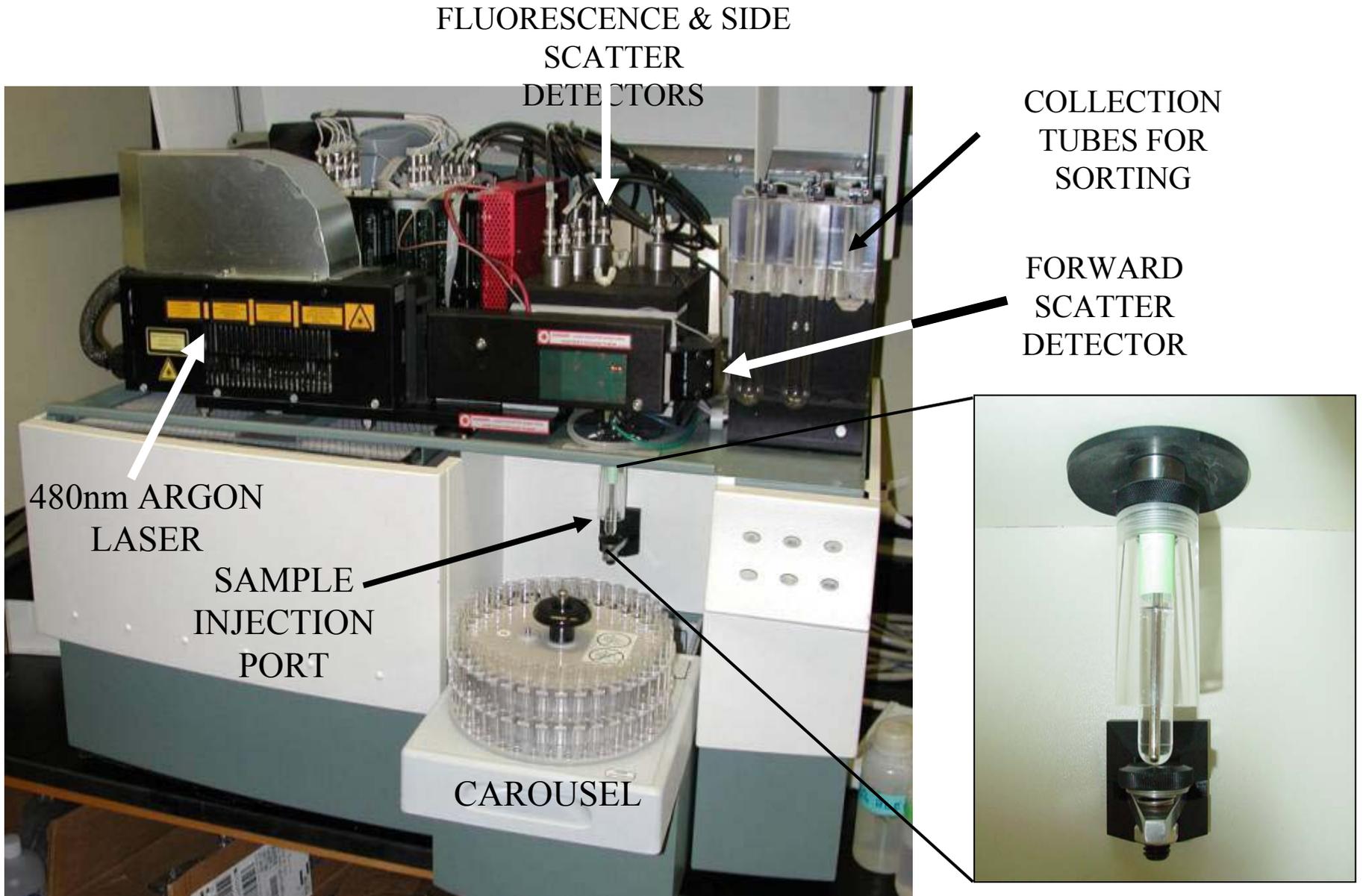
# Methods in Microbial Ecology

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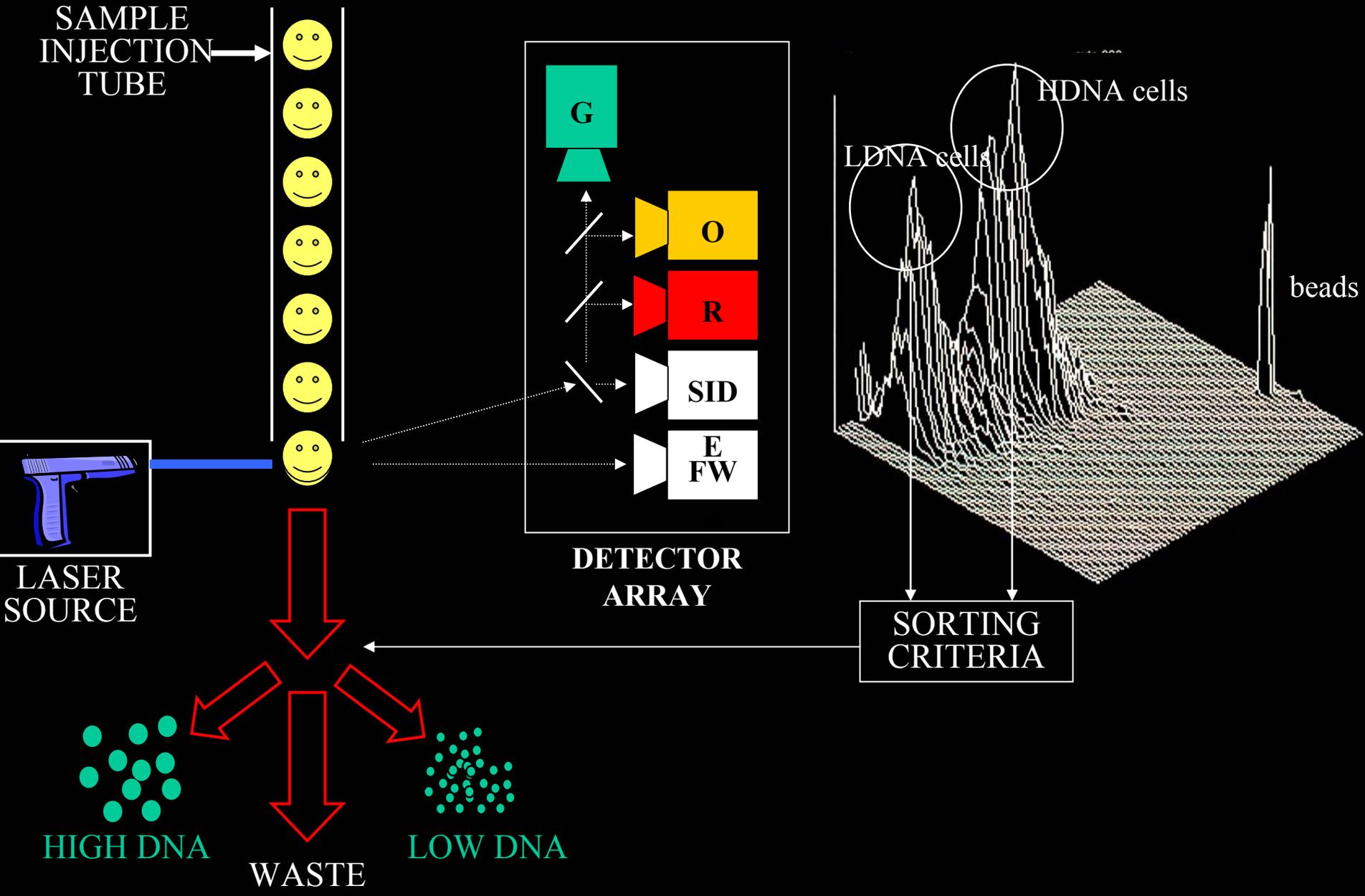
- Flow Cytometry
- Estimates of Bacterial Metabolism
  - Production
  - Respiration
  - Bacterial Growth Efficiency

# Microbial Lab Techniques: Flow Cytometry

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# Inside the Flow Cytometer

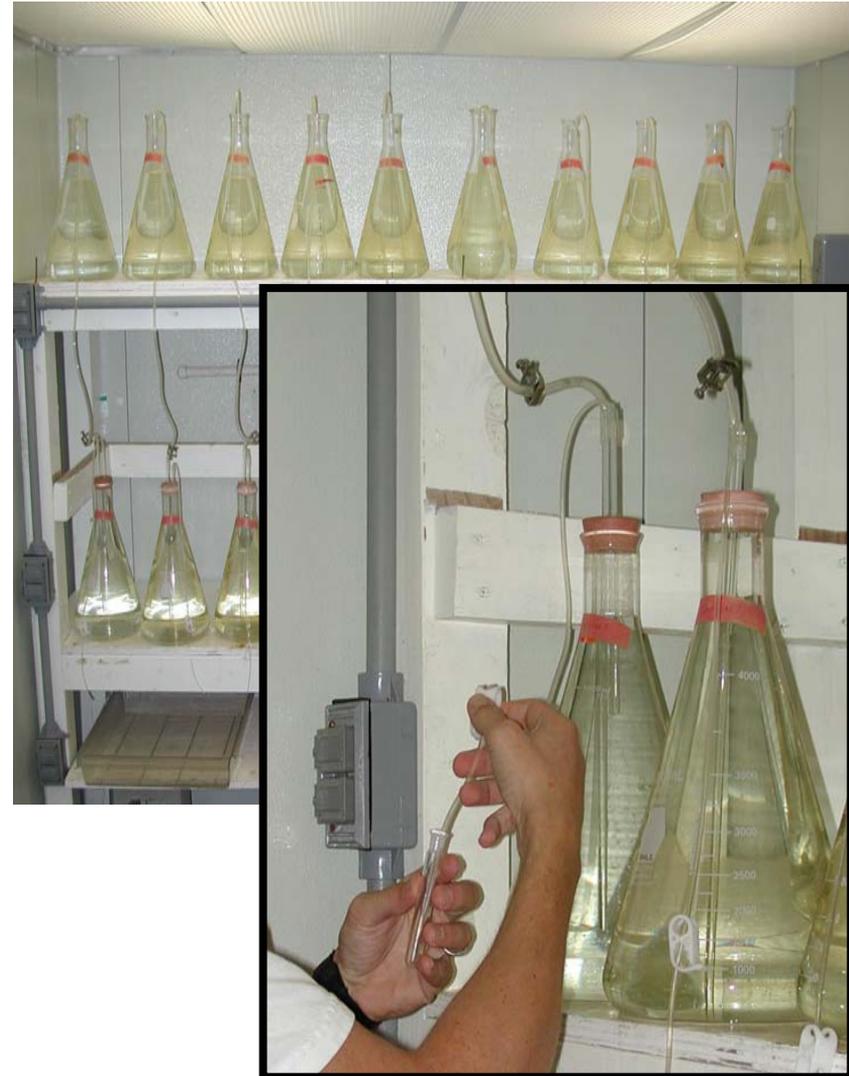




# Estimating Microbial Metabolism

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1. Bacterial Production (BP)
2. Bacterial Respiration (BR)
  - $O_2$  consumption over time
  - inlet mass spectrometry
3. Bacterial Growth Efficiency (BGE)



# Estimating Microbial Metabolism

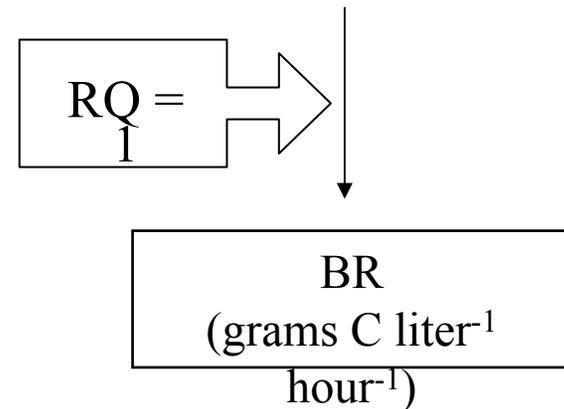
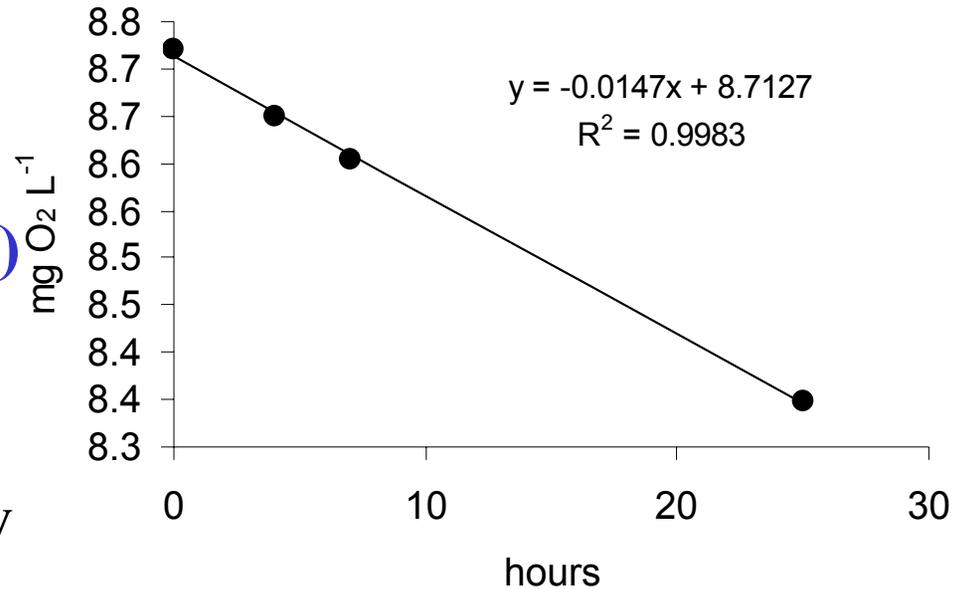
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1. Bacterial Production (BP)

2. Bacterial Respiration (BR)

- O<sub>2</sub> consumption over time
- inlet mass spectrometry

3. Bacterial Growth Efficiency (BGE)



# Estimating Microbial Metabolism

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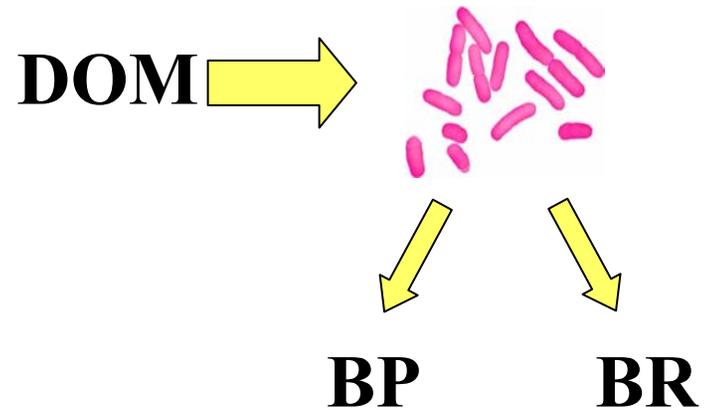
1. Bacterial Production (BP)

$$\text{BGE} = \frac{\text{BP}}{\text{BP} + \text{BR}}$$

2. Bacterial Respiration (BR)

**3. Bacterial Growth Efficiency (BGE)**

- production divided by total carbon consumption



# Objectives

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*“What is the effect of system-level nutrient enrichment on estuarine bacterioplankton communities?”*

## Today's Talk

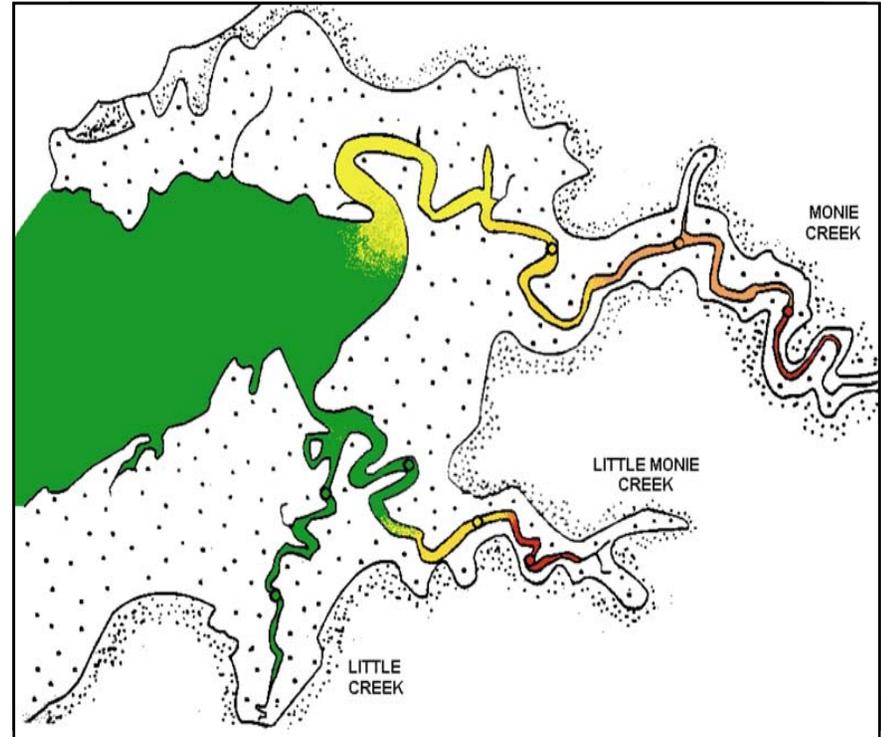
1. Monie Bay as a natural experiment
2. Response of bacterioplankton to nutrient enrichment
3. Effect of salinity on mediating this response
4. Conclusions and Implications

# Objective I: The natural experiment

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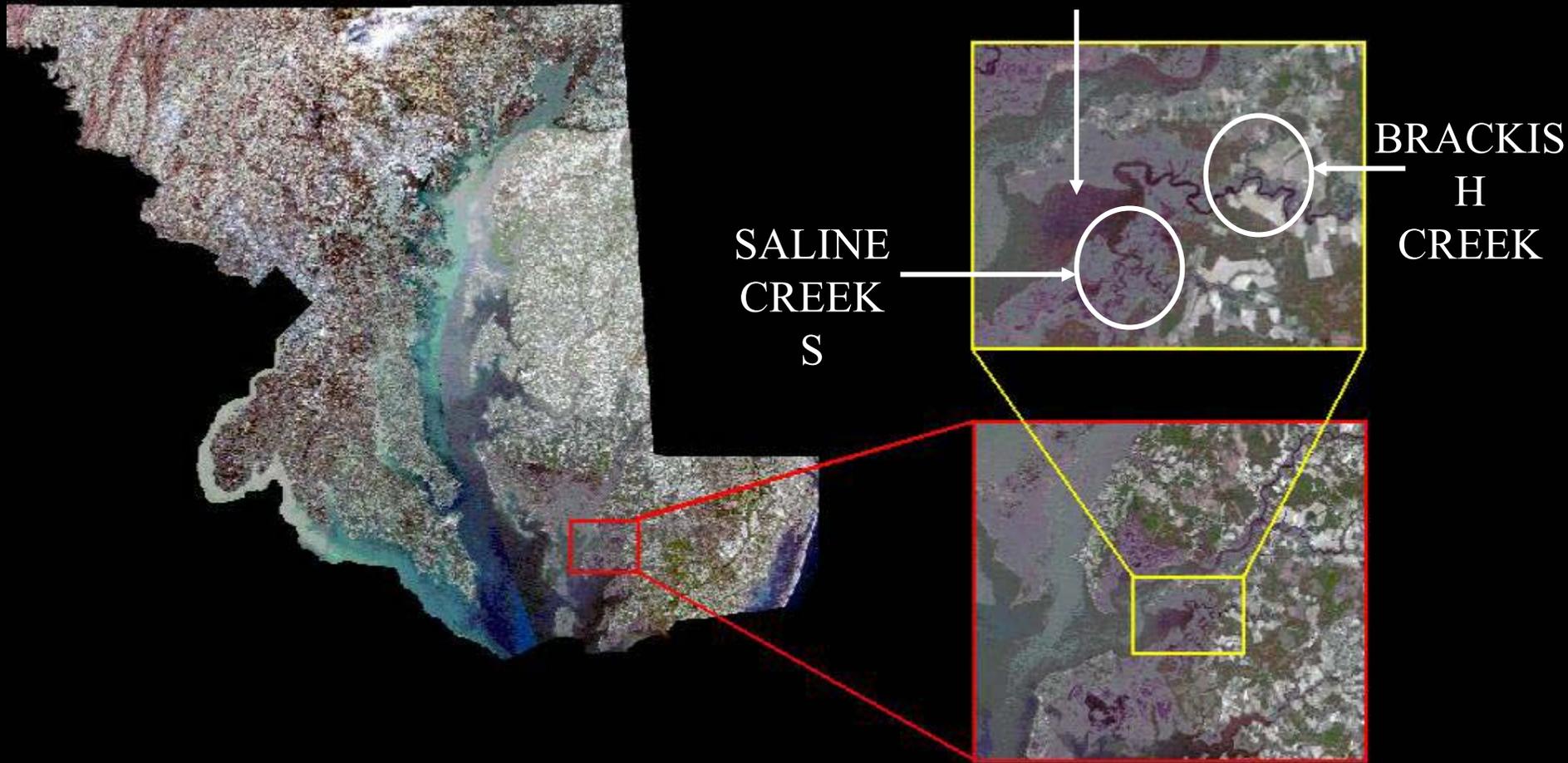
How do we evaluate the effect of nutrients on

- bacterioplankton?  
Small-scale nutrient enrichment experiments
- Large-scale field studies
- Large-scale enrichments
- Impacted systems function as “natural experiments”



# Study Site: Monie Bay Research Reserve

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Little Monie  
(LM)

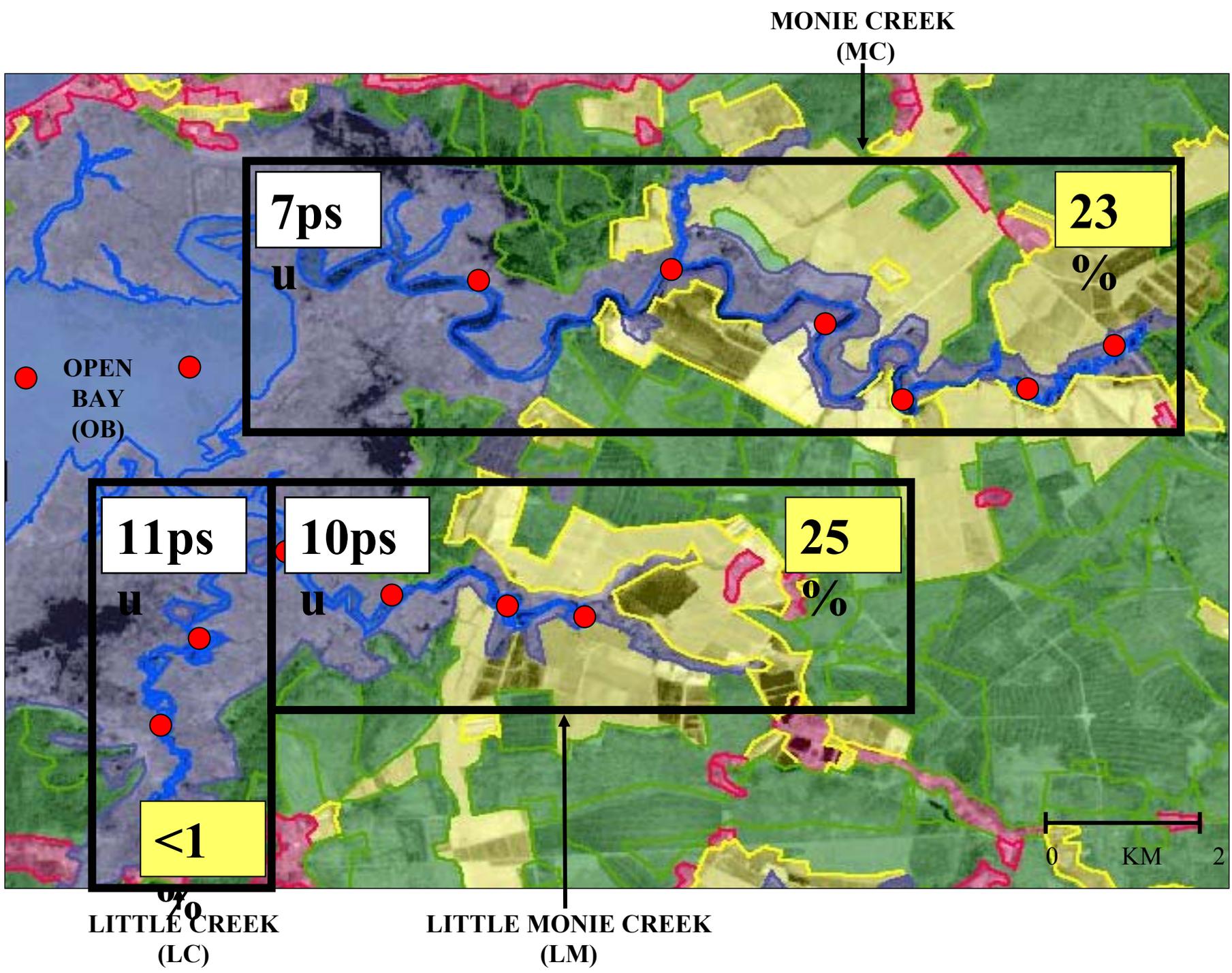


Little Creek  
(LC)



Monie Bay  
(OB)

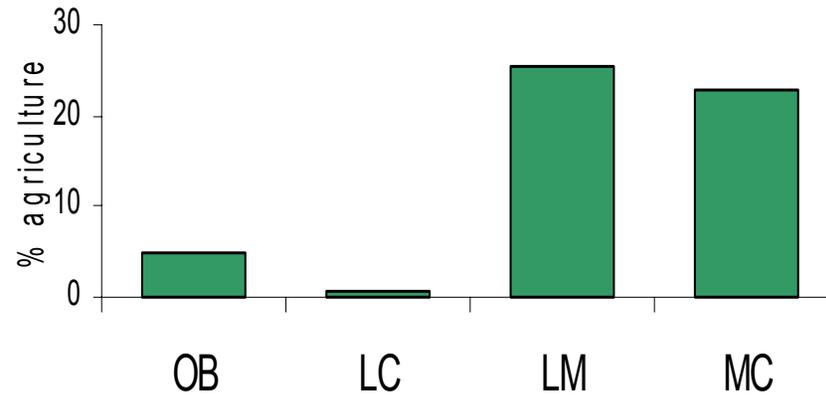




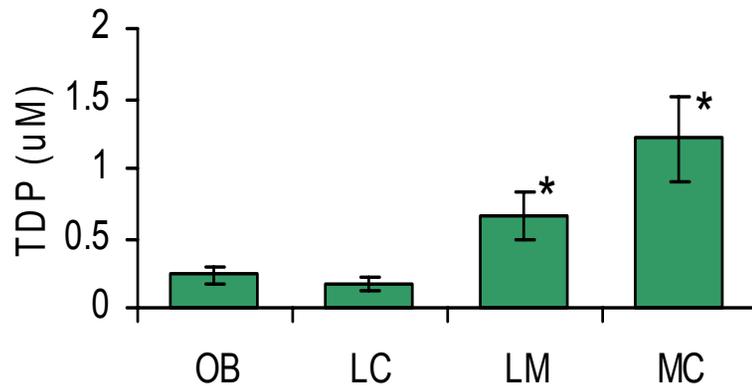
# Tidal Creek Nutrient Concentrations

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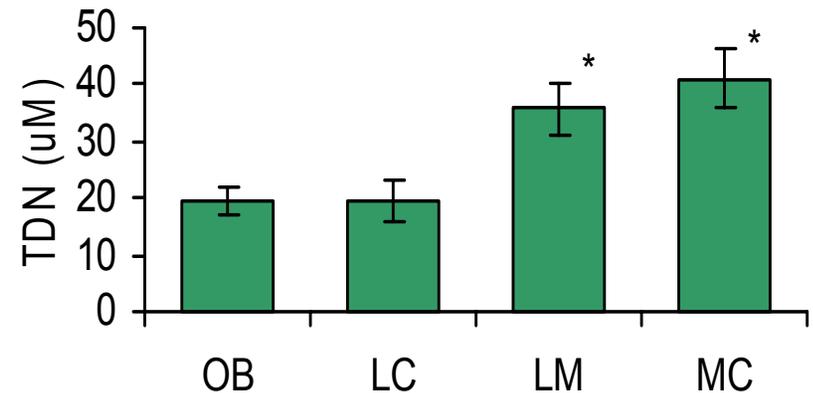
## Agricultural Land Use



## Phosphorus



## Nitrogen



# II

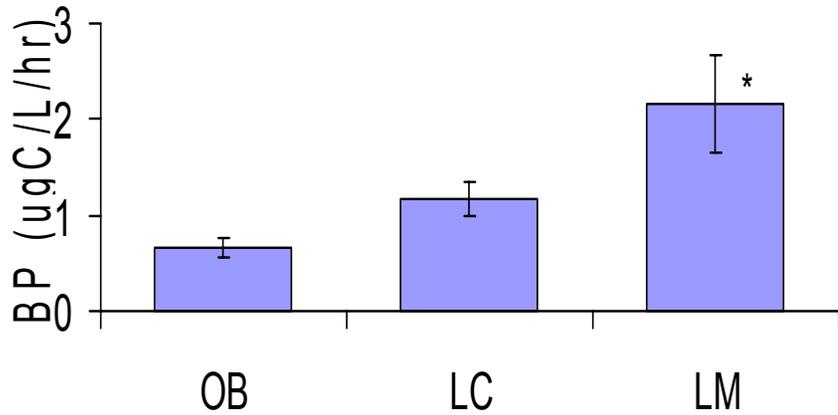
Does the bacterioplankton community respond to nutrient enrichment?

LM vs. LC

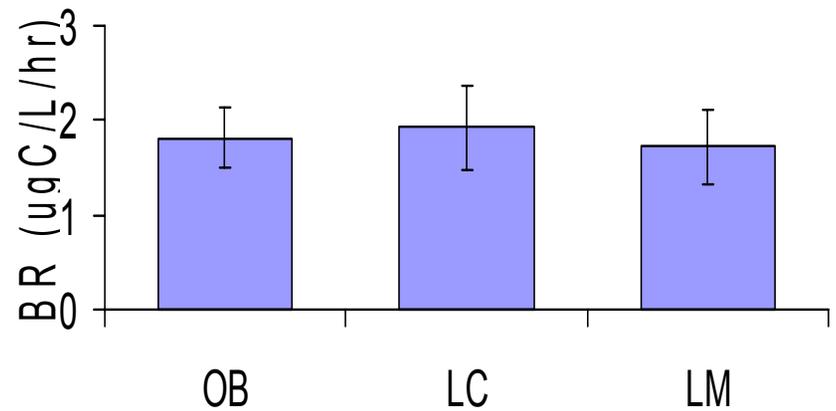
# Bacterioplankton Response to Enrichment

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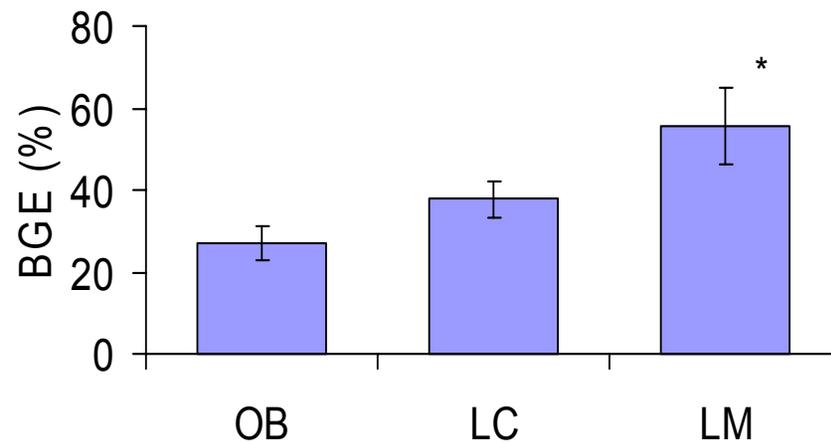
Bacterial Production



Bacterial Respiration



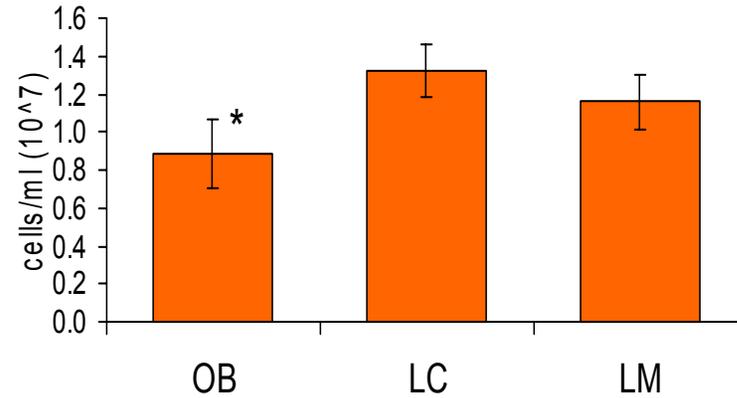
Bacterial Growth Efficiency



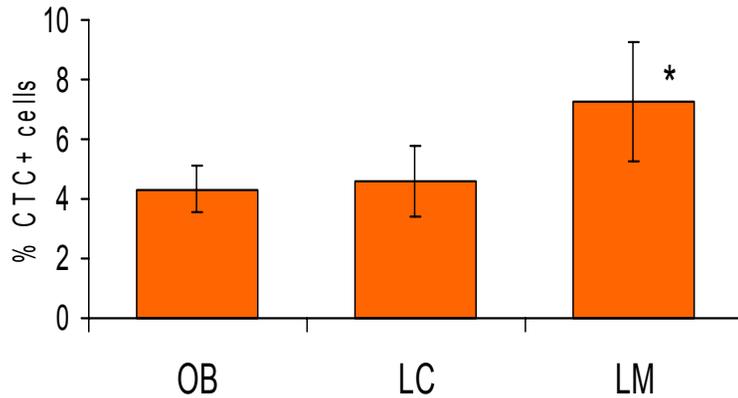
# Single-Cell Activity in Response to Enrichment

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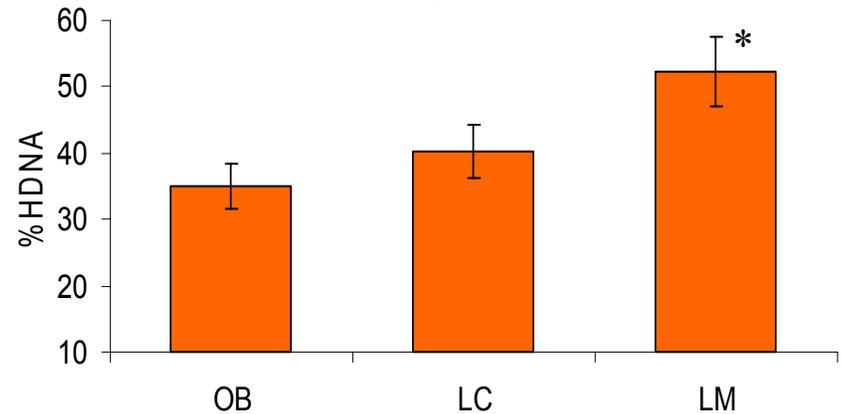
Bacterial Abundance



Percent Highly-Active Cells



Percent High DNA Cells



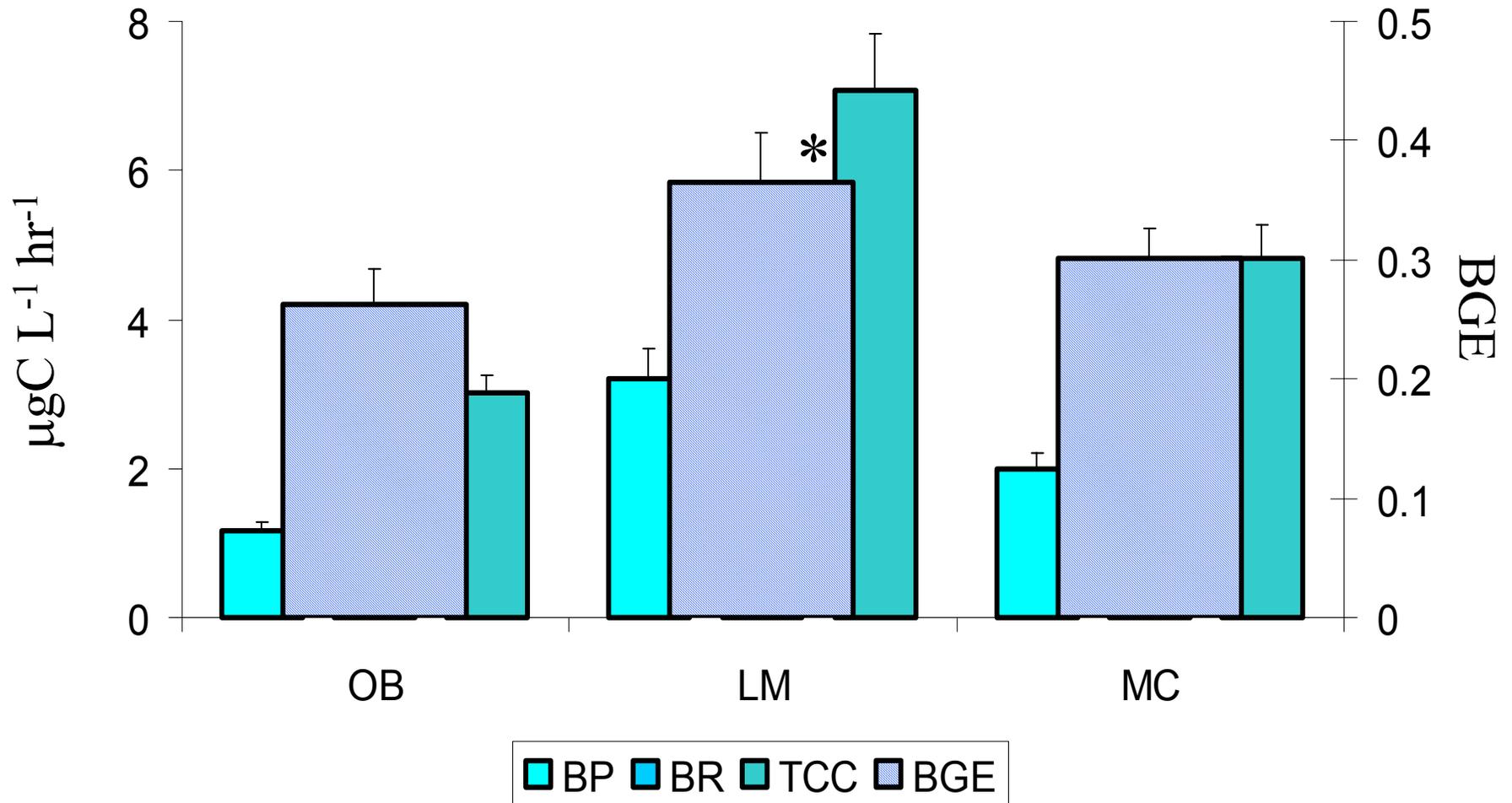
# III

Does salinity mediate the response to nutrient enrichment?

LM vs. MC

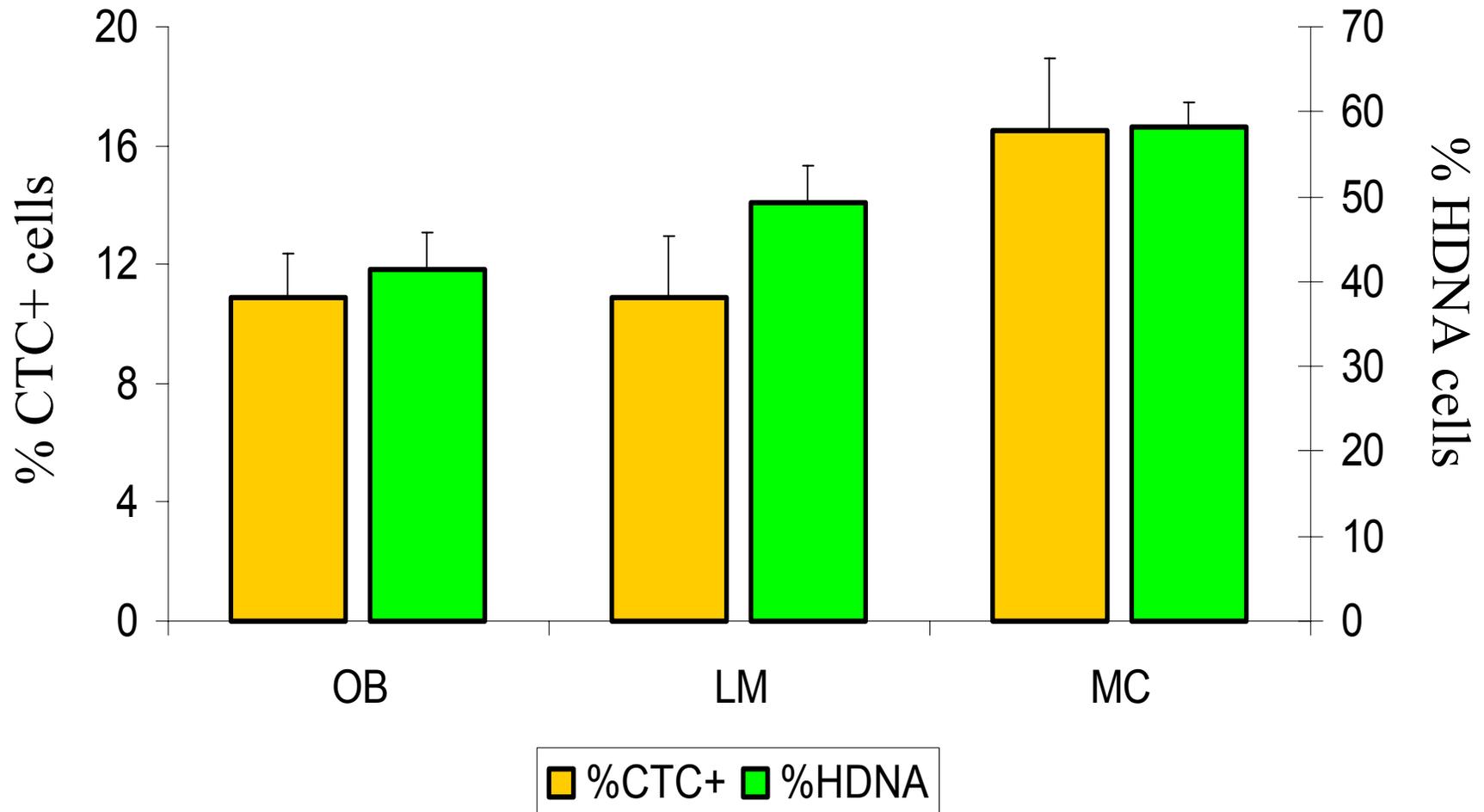
# Community Response to Nutrient Enrichment

- There is a muted response to enrichment in Monie Creek



# Single-Cell Response to Enrichment

- The proportion of highly-active cells is higher in Monie Creek, suggesting compositional differences in the assemblages



# What mediates the response to nutrients?

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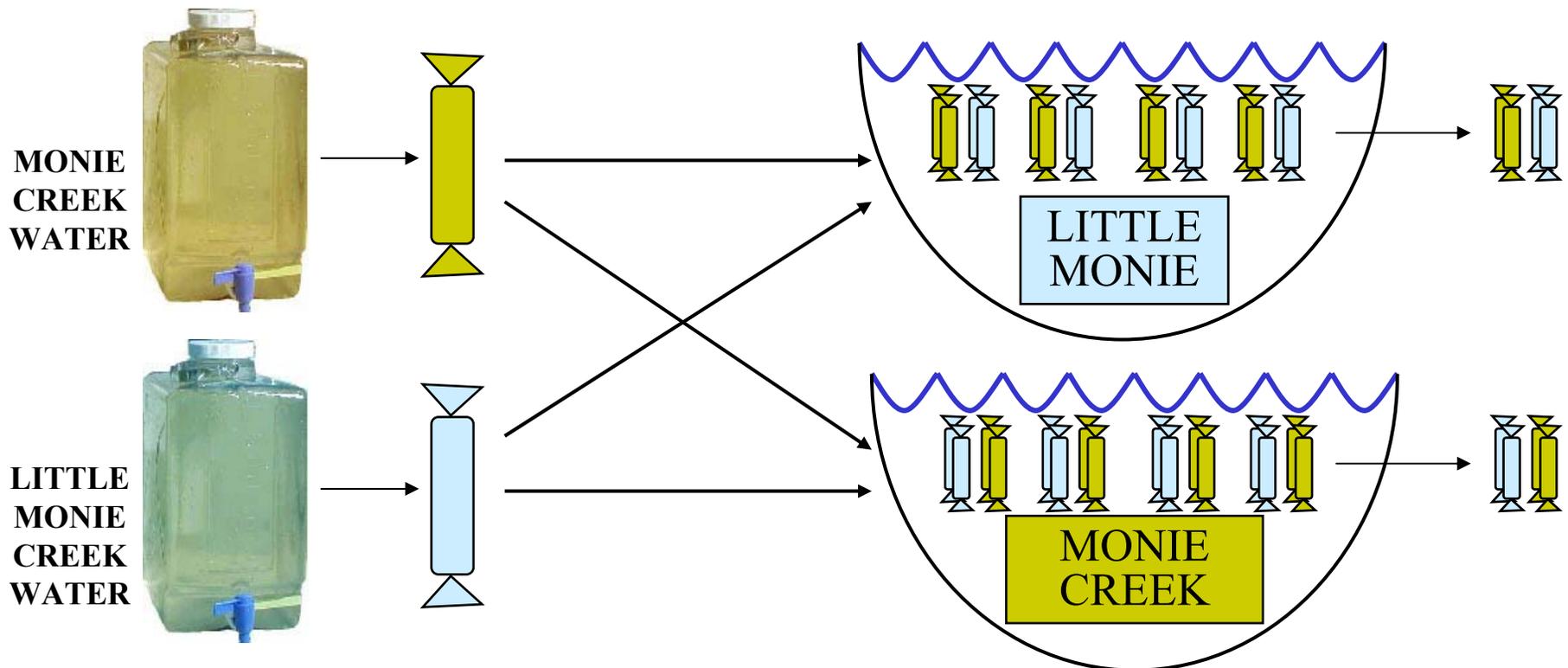
- Shifts in phylogenetic composition?
- DOM quality?
  - Transplant Experiment
  - Optical Characteristics of DOM
  - DOM Lability



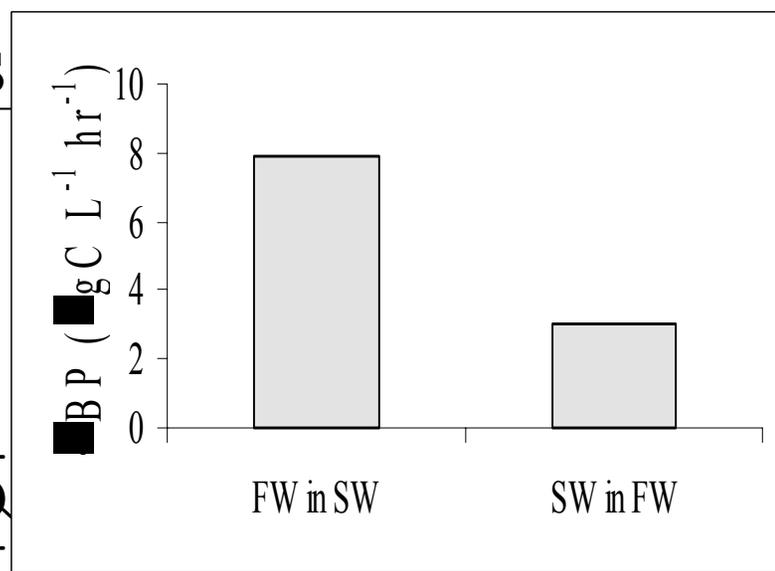
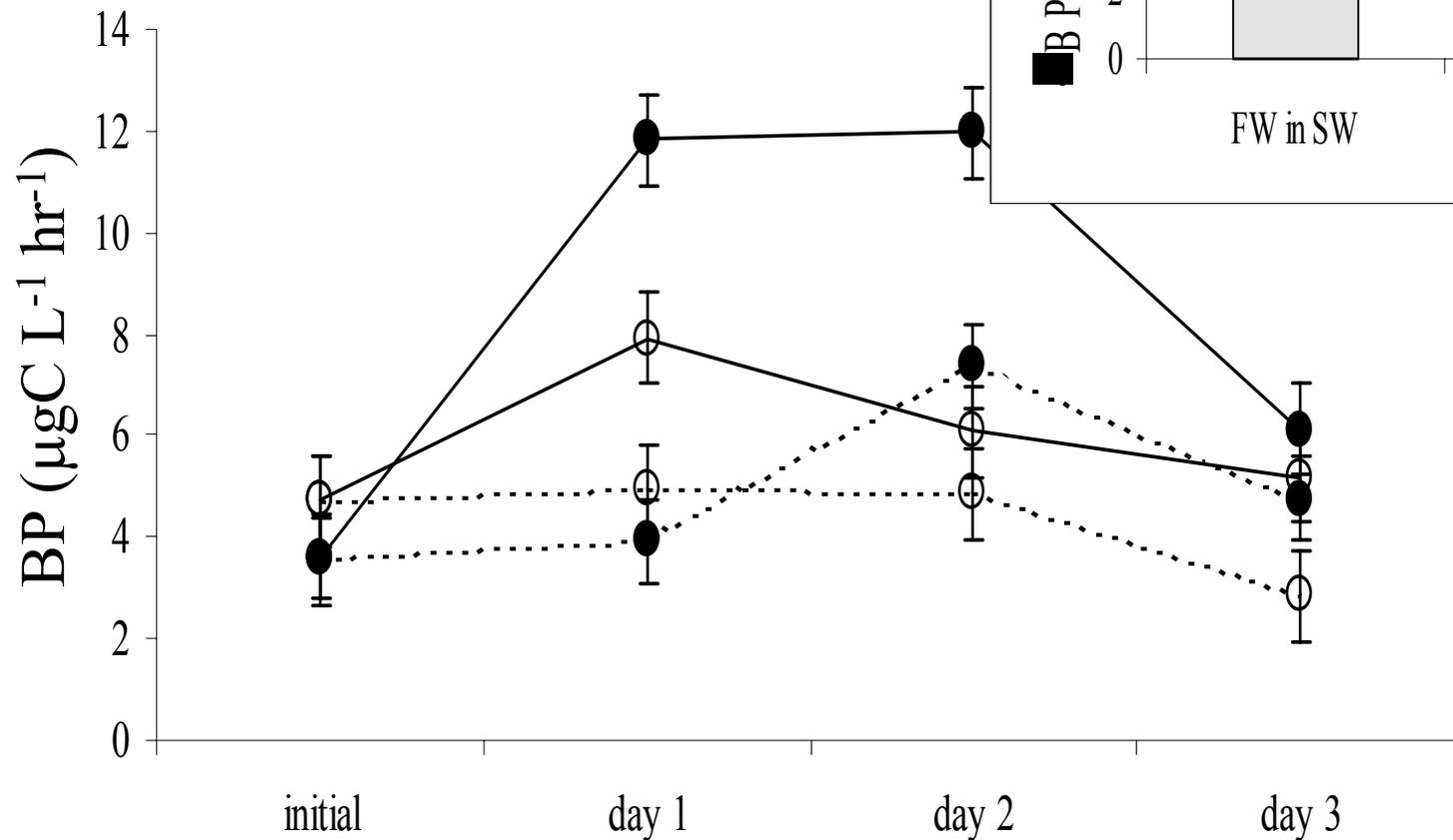
# Transplant Experiment

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1. Collect water, filter, and fill dialysis bags
2. Transplant dialysis bags
3. Transplant control bags
4. Harvest bags daily
5. Measure BA, BP, and single-cell activity



# Transplant Experiment: Results

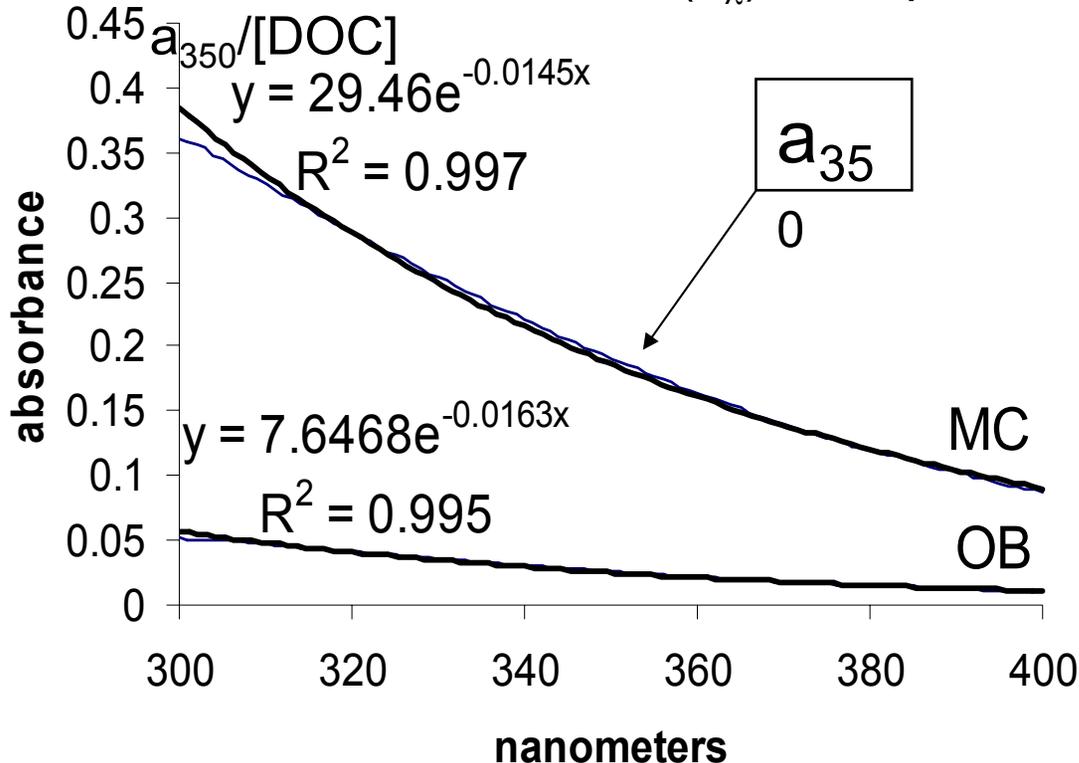


---○--- SW in SW    ---●--- FW in FW    —○— SW in FW    —●— FW in SW

# Optical Characteristics of DOM

Are there differences in substrate quality, as evidenced by CDOM?

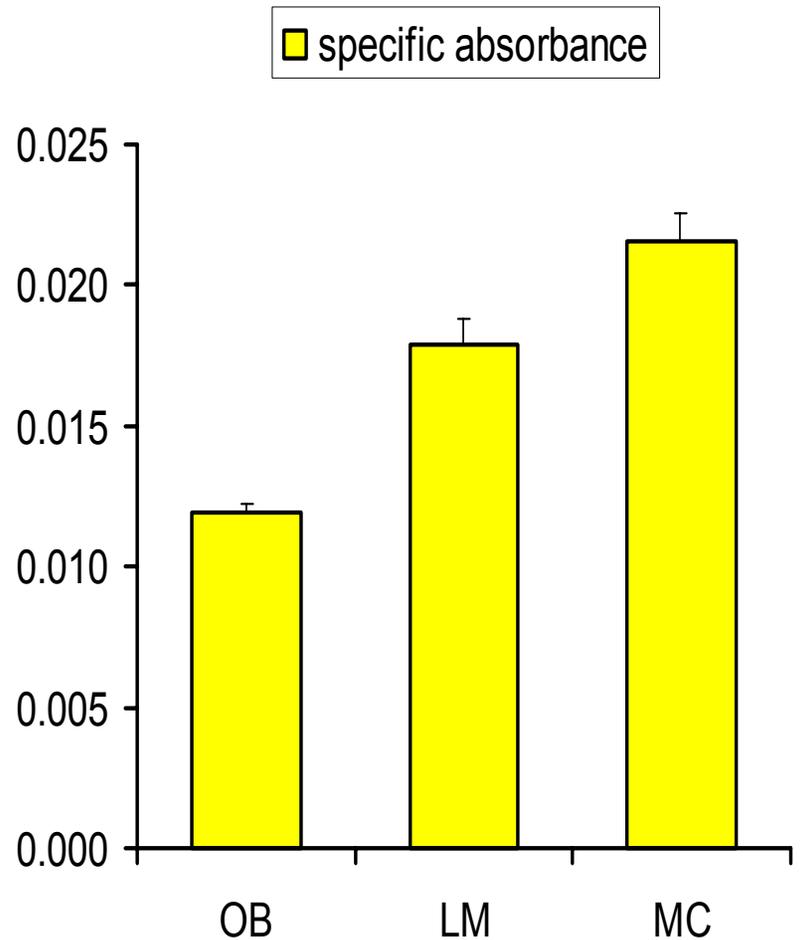
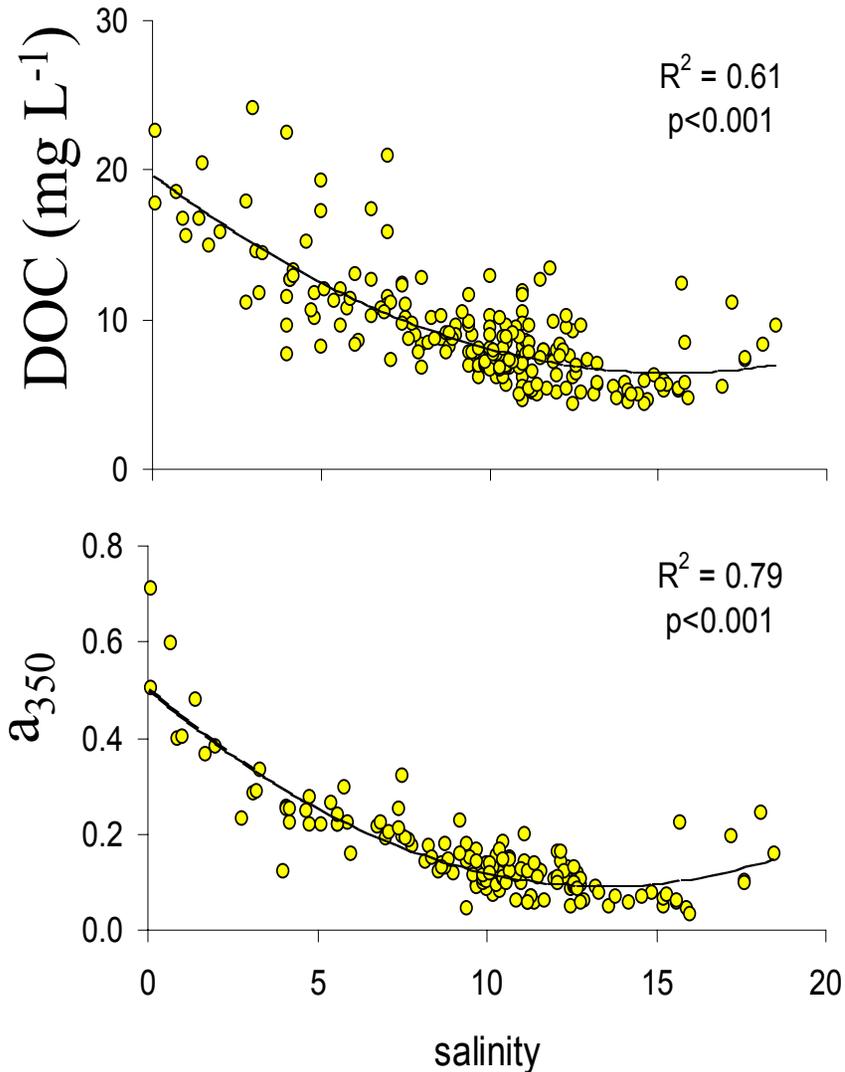
1. CDOM is an index of refractory, terrestrially derived organic matter
2. Absorption (A) spectra from 290-500nm
3. Calculate absorbance ( $a_\lambda$ ) and specific absorbance ( $a_{350}^*$ ) =



← A comparison of the absorbance of water from MC and the open bay.

# CDOM and DOM Quality?

- Monie Creek is enriched with DOC and CDOM



# DOM Lability Experiment

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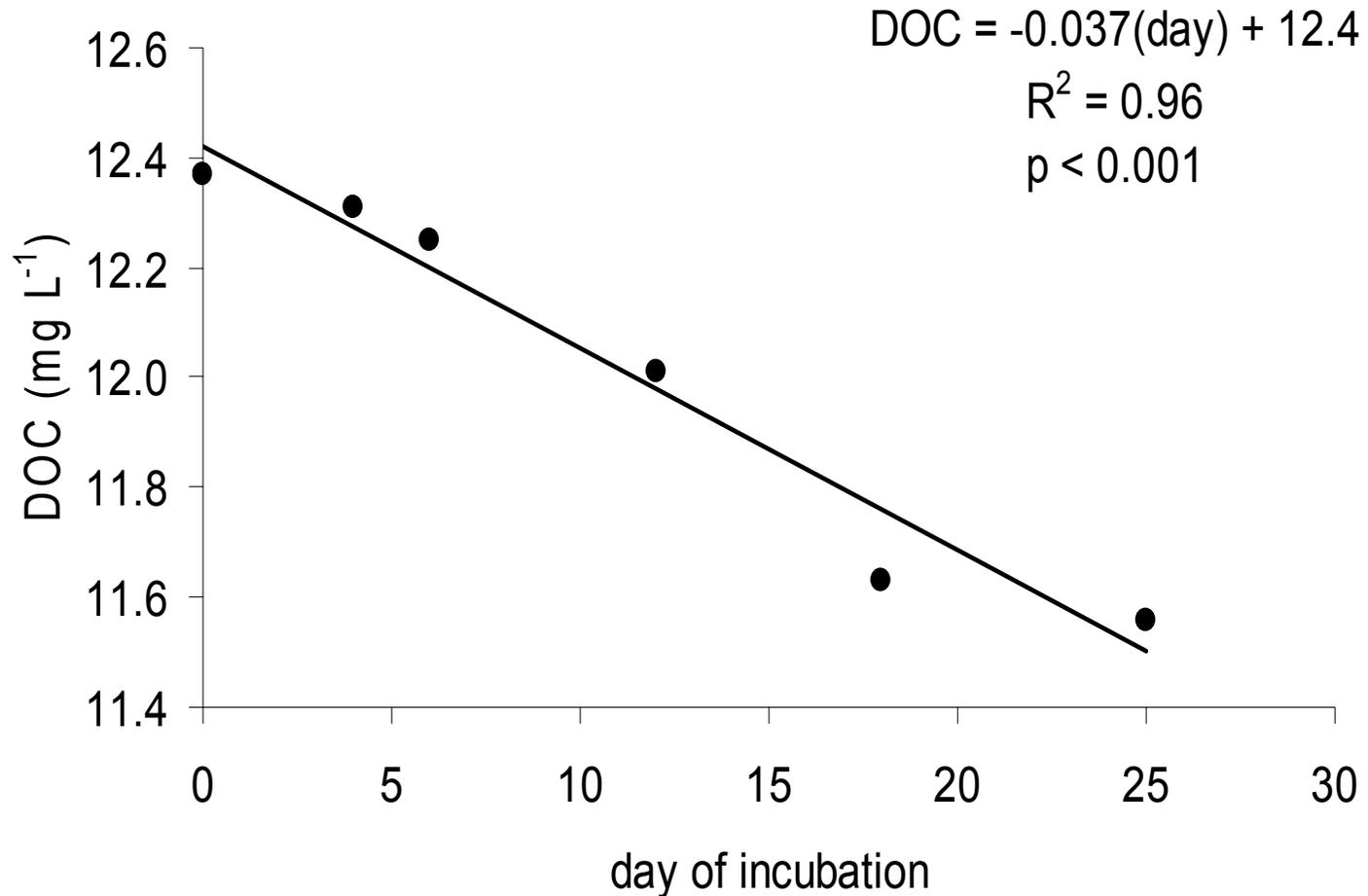
1. Collect water
2. 0.2 $\mu$ m filter 2L
3. Inoculate with resident bacterioplankton
4. Incubate for 4 weeks
5. Measure DOC



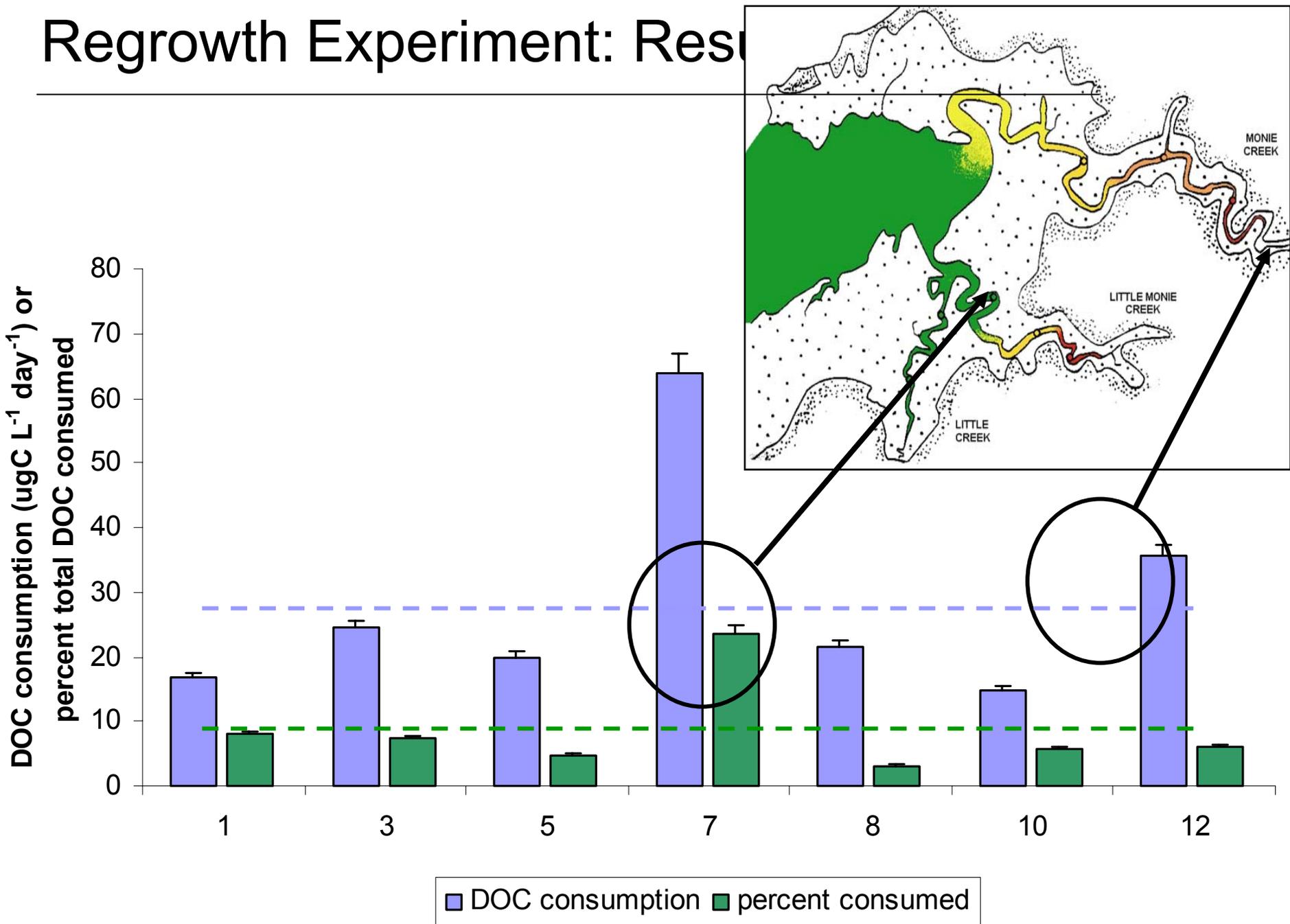
# DOM Lability Experiment: Results

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- Calculate  $\Delta\text{DOC}$  in  $\mu\text{gC L}^{-1} \text{ day}^{-1}$  (i.e. lability) and percent labile.



# Regrowth Experiment: Results



# Conclusions

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- I. Monie Bay as a **Natural Experiment**
  
- II. Effect of nutrient enrichment?
  - **Positive Response** on **Community** and **Cellular** levels.
  
- III. Effect of Salinity?
  - **Freshwater systems** have lower **DOM Quality**
  
- IV. Relevance and Implications?
  - **Source** and **Sink**
  - Indices of **Eutrophication** and **Management** implications
  - **Monie Bay** is a **Model Estuarine System**

